A Classic Cycle of Visualization

Goal: know that **visualization is an iterative process** and **a proper** visualization only obtained after a few iterations through the so-called cycle of visualization.

Storage
De-noising/filtering
Down-sampling…

Data

Simulation
Measurement
Records and logs …

Computer Scientists

Requirements

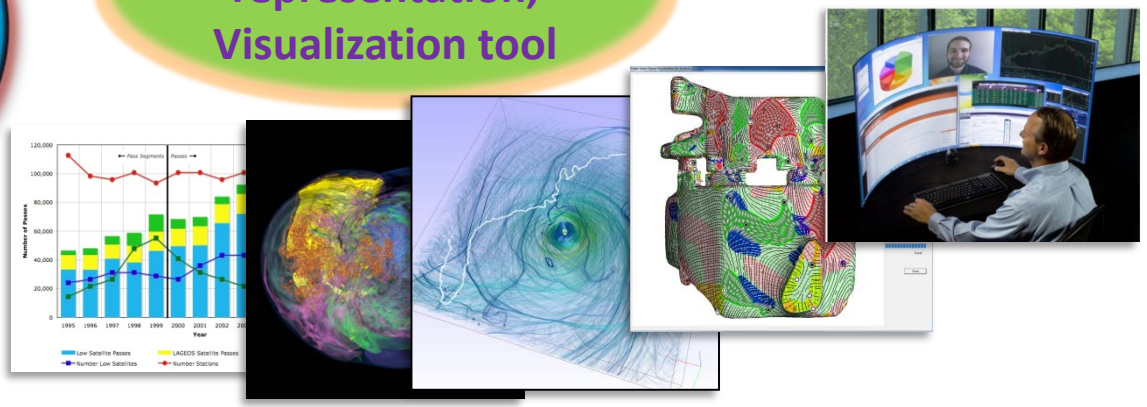
Validation
clarification

Domain practitioners

Algorithm development
System design
Data analysis
Data processing
Image composition…

Visual representation, Visualization tool

Presentation
Use cases
New findings…



Storage
De-noising/filtering
Down-sampling…

Data

Simulation
Measurement
Records and logs

Visualization is part of an iterative process!

Scientists

Validation

practitioners

Algorithm development
System design

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Data processing
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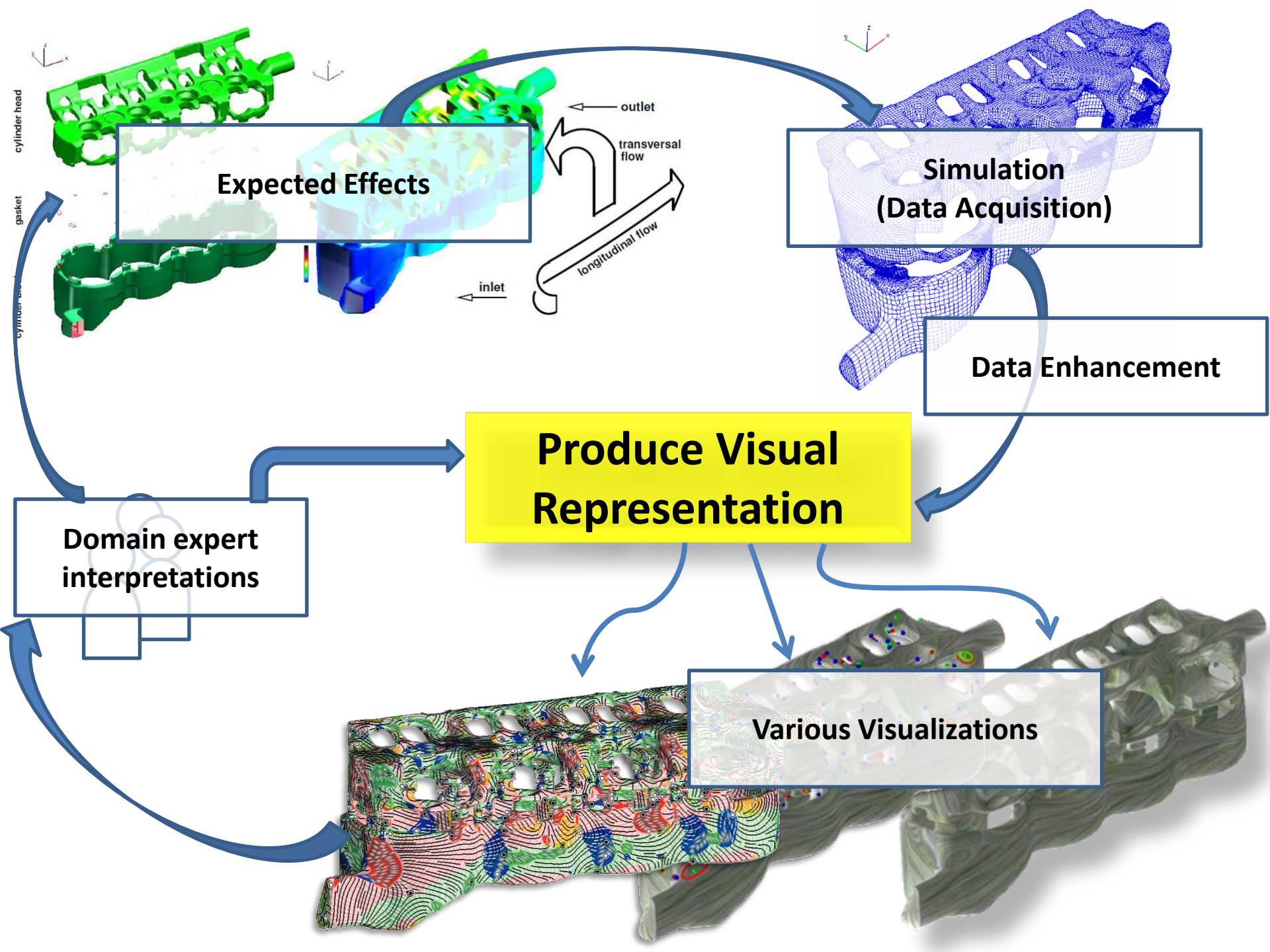
New findings…

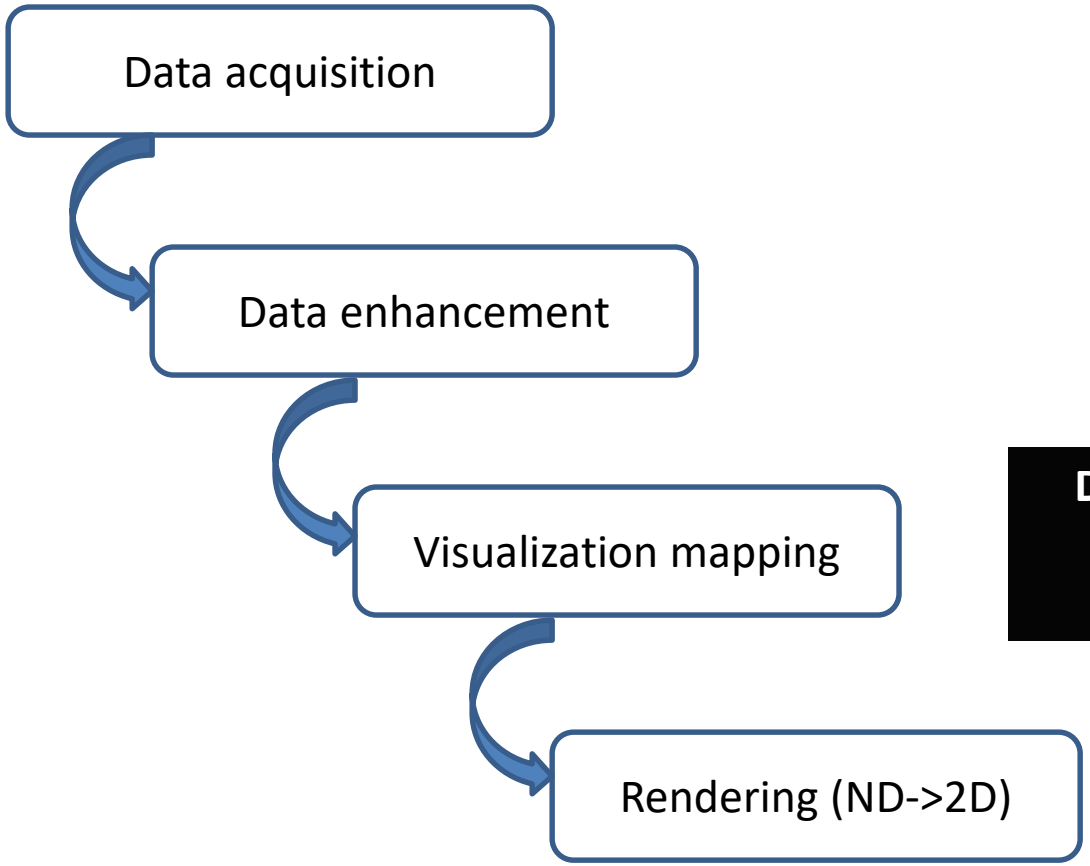
One example of how visualization and analysis can help with engineering design…


Expected Effects
outlet
transversal flow
longitudinal flow
inlet
cylinder head
gasket
Simulation (Data Acquisition)
Data Enhancement
Produce Visual Representation
Domain expert interpretations
Various Visualizations

Visualization Pipeline

Goal: know the **important steps** in the process of visualization for data-driven applications. Again, visualization is an iterative process.

Visualization Pipeline Overview



Data are generated.
What to collect/save?

Data are (pre-) processed.

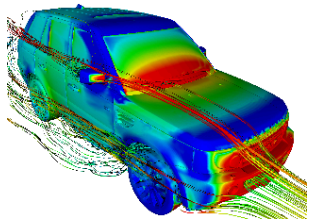
Data are mapped to visual primitives, e.g., colors, geometry, etc.

Images are generated.

Visualization Pipeline – Step 1

- **Data acquisition**
  - **Physical world** (***measured*** with equipment, observed)
    - Measurements and observations, e.g., CT/MRI, GIS (MB), seismic data (GB/TB), Hubble Space Telescope (TB)…

  - **Theoretical world** (***computed***)
    - Mathematical and technical models -> e.g., structural mechanics (MB), CFD simulation (GB-TB/steady, TB and peta-scale for time-series)

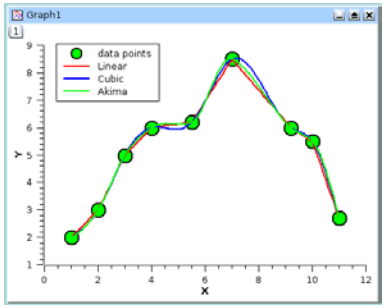


  - **Artificial world** (***documented***/log…)
    - Data that is designed, e.g., **surveys** (KB), drawings (MB), game industry (GB)
    - Logs, records, and archives (TB)

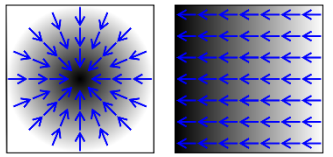
What do your emails and posts on social media belong to?

Visualization Pipeline – Step 2

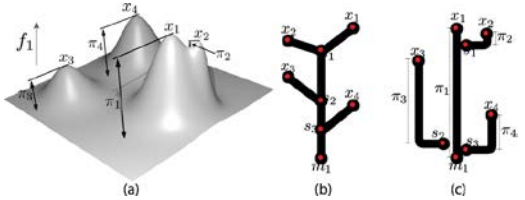
- **Data enhancement**
  - **Filtering** (e.g., smoothing), denoising
  - **Handle incomplete data** (due to equipment failure)
  - **Resampling** (e.g., on a different-resolution grid)
    - Reduce data size (needed for big-data processing)
    - Calibrate different data sources

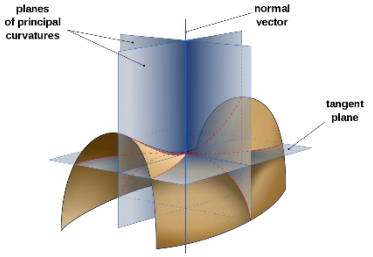


  - **Data interpolation** (e.g., linear, cubic, basis,…)
    - **For continuous data only and can be used in different tasks!!**



  - **Analysis** (*may be separated into a different step of the visualization pipeline*)
    - Data derivation (e.g., gradients, limits, curvature, closed sub-sets, structure,…)
    - *Feature/pattern identification, classification, dimensionality reduction*

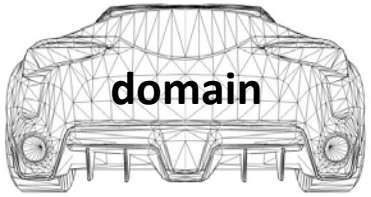


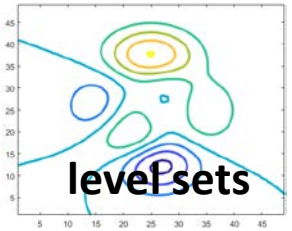


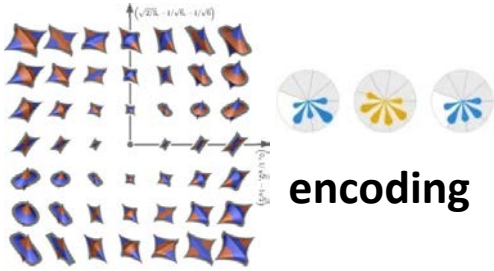
Visualization Pipeline – Step 3

Visualization mapping = map/encode data to something that is renderable

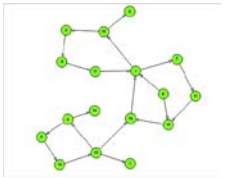
1. Choose proper **geometric** elements
   - Grids (e.g., the original meshes, images, etc.) – *typically come with the data*.
   - Iso-contour/streamlines/surface calculation (create continuity or discontinuity) – *need to be extracted*
   - Glyphs, icons determination – *need to be constructed, map data to the shape, orientation, size, boundary of the glyphs/icons*
   - Graph-layout calculation (determine geometric locations/coordinates)

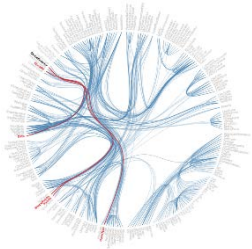






2. Choose **proper** **optical attributes** for the geometric elements as above
   - color, illumination, transparency, texture…

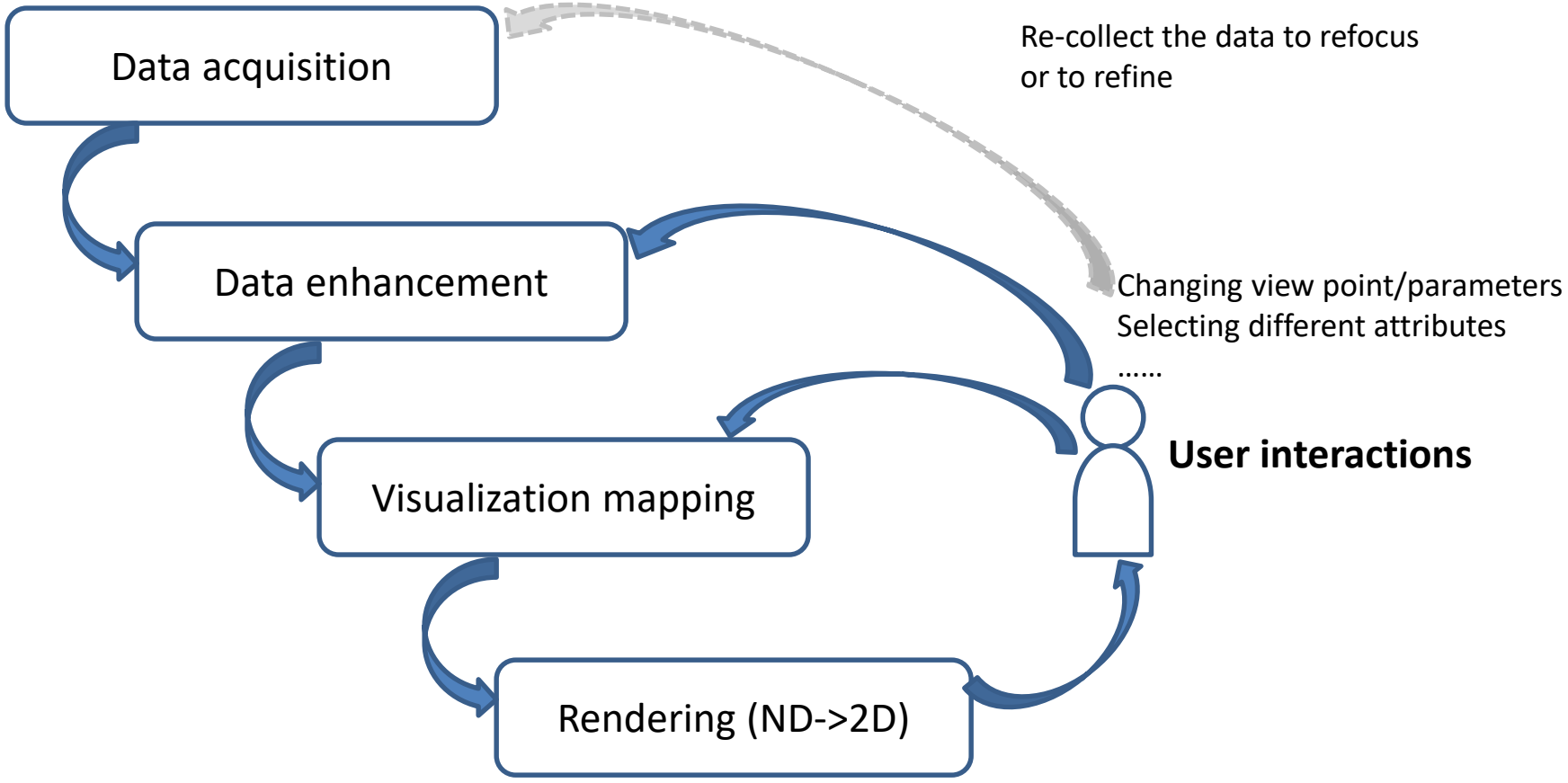




Visualization Pipeline – Step 4

- **Rendering** = image generation with **Computer Graphics** techniques (make it **visible**!)
  - Viewpoint selection (for user interactions)
  - Visibility calculation (given a viewpoint)
  - **Illumination (determine pixel colors)**
  - **Compositing (combine transparent objects, color blending, …)**
  - *Animation (a sequence of static images)*

Visualization Pipeline Overview



When considering the earlier cycle of visualization

Some Useful Principles